United States Patent Office

2,993,768

Patented July 25, 1961

2,993,768

LIQUID MONOFUEL AND METHOD OF FORMING

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No Drawing. Filed Sept. 22, 1955, Ser. No. 536,054

19 Claims. (Cl. 52—.5)

This application is a continuation in part of copending application, Serial No. 447,421 filed August 2, 1954, now abandoned which is a continuation in part of Serial No. 353,240 filed May 5, 1953, now abandoned.

This invention relates to a liquid monofuel and particularly to a liquid monopropellant for use in reaction chambers or combustors of rocket and jet engines to provide hot gases having predictable characteristics. The invention further relates to a method of adjusting the decomposition and storage characteristics of a liquid monofuel.

In the field of propellants for use in reaction chambers or combustors of rocket and jet engines, alkylene oxides, such as ethylene oxide, have been proposed for use as monopropellants, since these substances are inflammable and explosive and have other desirable properties. There are some types of combustors in which alkylene oxides, such as ethylene oxide, alone are unsuitable because of a decomposition temperature which is either too low or too high. Moreover, the autoignition temperature and vapor pressure of alkylene oxides, such as ethylene oxide and propylene oxide, are greater than is necessary or practical for combustor operation and the storage density is so low that, for example, only an inadequate amount of fuel may be carried in aircraft in which a particular combustor is employed. The low storage density of alkylene oxides, such as ethylene oxide, is a particular disadvantage of these fuels because the problem of increasing the range of jet and rocket operated aircraft is of great significance.

The principal object of the present invention is to provide a liquid monofuel solution, characterized by a selected decomposition temperature and freezing point, and a low autoignition temperature and vapor pressure, and a high storage density.

Another object of the invention is to provide a liquid monofuel having a relatively low autoignition temperature and vapor pressure and which also has a selected freezing point and a relatively high shock stability and storage density, making possible an increased range in aircraft in which the monofuel is used.

Another object of the invention is to provide a method of adjusting the decomposition temperature, autoignition temperature and storage density of a liquid monofuel.

These and other objects of the invention are elaborated and become more apparent in the following description.

According to the present invention, the inadequacies of an alkylene oxide as a liquid monofuel are largely overcome by the combination of one or more alkylene oxides (or alkyl nitrates which may be substituted for alkylene oxides) with one or more alkylene carbonates and one or more nitroalkanes. Alkylene carbonates and nitroalkanes have in common the effect of reducing the autoignition temperature and vapor pressure of alkylene oxide either alone or in combination with alkyl nitrate or of alkyl nitrate alone, and of increasing the storage density thereof, so that the addition of alkylene carbonate and nitroalkane to alkylene oxide improves the decomposition and storage characteristics of a liquid monofuel. Moreover, the use of both alkylene carbonate and nitroalkane, in addition to alkylene oxide (or alkyl nitrate) provides a liquid monofuel having a predictable and adjustable decomposition temperature, storage density and power output.

However, it has been discovered that by adding an alkylene carbonate to an alkylene oxide or alkyl nitrate it is possible to reduce the decomposition temperature of the resultant mixture, and that by adding a nitroalkane to an alkylene oxide or alkyl nitrate composition it is possible to increase the decomposition temperature thereof. Furthermore, alkyl nitrates can be substituted in whole or in part for alkylene oxides in such compositions. Complete substitution, however, raises the threshold of physical shock stability and it is preferred to keep at least some alkylene oxide in all fuel compositions for safe handling. Accordingly, by varying the percentages of alkylene carbonate and nitroalkane with relation to each other it is possible to achieve a liquid monofuel having the precise decomposition characteristics required for combustors in which such a fuel is used.

Where the amount of alkylene carbonate is relatively large in comparison with the amount of nitroalkane, the decomposition temperature of the liquid monofuel is relatively low. On the other hand, where the amount of nitroalkane is large in comparison with the amount of alkylene carbonate, the decomposition temperature is substantially increased. In either case, however, the autoignition temperature and vapor pressure of the resultant solution are rendered relatively low and the storage density of the solution is made relatively high.

In view of the above, it is clear that the exact proportions of the elements in the liquid monofuel will vary in different applications depending upon the exact characteristics which it is desired to attain for the combustor in which the fuel is to be used. Indeed, it is not always necessary to use both of these ingredients and in some fuel compositions only one of them is used.

As here employed, the term "decomposition temperature," means the same as what is frequently referred to as "the total temperature" which is the maximum flame temperature in the reaction chamber or combustor. A preferred liquid monofuel is characterized by a decomposition or total temperature below 2200° F., since higher temperatures are unsuitable for gas turbine engines and require special cooling systems for rocket engines. On the other hand, the minimum decomposition temperature which is useful in a liquid monofuel is about 1200° F. Such a temperature is suitable for a gas producer used for tank pressurization.

The combination of a nitroalkane and an alkylene oxide alone, (which may or may not also include an alkyl nitrate) without the addition of an alkylene carbonate results in acceptable performance for some situations, but is usually characterized by excessively high decomposition temperatures which may be of the order of 3500° F. Hence, special cooling equipment is necessary for rocket use and the fuel is usually unsuitable for gas turbine use.

A preferred decomposition temperature for a liquid monofuel is about 1800° F., and this is the approximate decomposition temperature of ethylene oxide used alone. However, as indicated above, it is undesirable to use ethylene oxide alone, since the autoignition temperature and vapor pressure are high, and the storage density is low. It is desirable to keep vapor pressure at a minimum in order to permit the use of relatively lightweight fuel tanks, instead of strong and heavy ones.

In a preferred form, the present invention contemplates adding an alkylene carbonate, such as ethylene carbonate, and a nitroalkane, such as nitromethane, in approximately equal parts by weight relative to each other, to a major portion of an alkylene oxide, such as ethylene oxide, which may also include some alkyl nitrate, such as n-propyl nitrate. Since nitromethane, for example, has the effect of raising the decomposition temperature, and ethylene carbonate, for example, has the effect of lowering

the decomposition temperature, in about the same proportion, a solution containing equal parts of ethylene carbonate and nitromethane with ethylene oxide, for example, has approximately the same decomposition temperature as ethylene oxide alone. The combination liquid monofuel solution has the desired decomposition temperature but is greatly improved relative to such factors as autoignition, vapor pressure and storage density.

There is a practical minimum relative amount of alkylene oxide which must be employed in a liquid monofuel according to this invention when no alkyl nitrate is used. This minimum is approximately 40% by weight. Two practical considerations determine this minimum. The first consideration is the freezing point of the resultant solution and the second is the stability or shock insensitivity of the resultant solution.

Ethylene oxide, for example, is characterized by a freezing point lower than that of ethylene carbonate, for example, or nitromethane, for example, and its use in substantial proportion is necessary to keep the resulting freezing point of the mixture below approximately −65° F. If the freezing point of the fuel were above this temperature the fuel would tend to freeze up in certain situations, particularly in high altitude use, which woud be a considerable disadvantage.

With respect to the second consideration, alkylene oxides and ethylene oxide in particular, have a relatively high stability or shock insensitivity, and are relatively difficult to explode. Therefore, when alkyl nitrates, such as n-propyl nitrate, are substituted for them, this substitution is ordinarily only partial. Nitromethane and ethylene carbonate, as examples of nitroalkanes and alkylene oxides respectively, however, are relatively easy to explode and difficult to handle. It follows that substantial proportions of ethylene oxide or its equivalent should be employed so that the resulting fuel will be safe to handle. For example, preferable ranges in this liquid monofuel composition are by weight: 40–80% ethylene oxide, 5–30% nitramethane, and 5–30% ethylene carbonate.

The combination of an alkylene oxide such as ethylene oxide, an alkylene carbonate such as ethylene carbonate, and a nitroalkane such as nitromethane, forms a true solution which is miscible in all proportions of the three elements, as is essential for a satisfactory liquid monopropellant. Because of this complete miscibility, the considerations taken into account when the fuel is prepared are the properties which it is desired to attain, and particularly the exact decomposition temperature required.

The following examples illustrate various combinations which comprise a liquid monofuel according to this invention.

Ordinarily, a major proportion of the fuel comprises one or more alkylene oxides. Such oxides may, for example, be selected from the group comprising ethylene oxide, propylene oxide, 1,3 butadiene dioxide and related diene and triene oxides and dioxides of the lower order olefins and paraffins.

To a considerable extent alkyl nitrates may be substituted for a portion of the alkylene oxides. Among these compounds are methyl nitrate, ethyl nitrate, n-propyl nitrate, isopropyl nitrate and various butyl nitrates such as n-butyl nitrate. Indeed, for some purposes the simple binary combination of an alkylene oxide, such as ethylene oxide, with an alkyl nitrate, such as n-propyl nitrate, will form a satisfactory liquid monofuel. For example, the binary composition can comprise fifty percent of each. Ordinarily, some alkylene oxide is used in combination with the other fuel components of this invention even when it is largely replaced by alkyl nitrate, since the alkylene oxides reduce the danger of explosions in handling. Moreover, various combinations of alkyl nitrate may be used as a fuel component as well as a single species.

Alkylene carbonates may also be used in the liquid monofuel of this invention. They may be used as mixtures or as an individual species such as ethylene carbonate or propylene carbonate. They may also be entirely omitted from the fuel composition.

Nitroalkanes may also be used in the liquid monofuel of this invention. They may be used as mixtures or as an individual species such as nitromethane, nitroethane, a nitropropane or a nitrobutane. The combination with a major proportion of an alkylene oxide of substantially equal proportions by weight of nitroalkane and alkylene carbonate constitutes the preferred form of the invention. They may also be entirely omitted from the fuel composition.

The following detailed examples illustrate specific fuel compositions according to this invention. The various components of the compositions according to this invention. The various components of the compositions are generally readily replaced by the several alternative components described above.

Example 1

A specific preferred example of a liquid monofuel having a decomposition temperature of approximately 1800° F. and a freezing point of approximately −65° F., comprising 25% ethylene carbonate, 25% nitromethane and 50% ethylene oxide, in proportion by weight. To achieve a lower freezing point and yet retain the desired decomposition temperature, the amount of ethylene oxide may be increased while still employing about equal proportions by weight of the other ingredients.

Example 2

A specific example of a solution having a freezing point of approximately −100° F. and a decomposition temperature of approximately 1800° F., is 10% ethylene carbonate, 10% nitromethane and 80% ethylene oxide, all proportions being by weight.

Example 3

A decomposition temperature of approximately 2200° F. is obtained with a liquid monofuel comprising 20% by weight of nitromethane, 5% by weight ethylene carbonate and 75% by weight ethylene oxide. Although a fuel decomposition temperature of about 1800° F. is preferred for flight of substantial duration, a decomposition temperature may rise as high as about 2200° F. for short flights. For such situations it is merely necessary to increase the nitromethane content relative to the ethylene carbonate by amounts such that the desired decomposition temperature will be achieved.

Example 4

It may be desirable to lower the decomposition temperature of a liquid monofuel to approximately 1200° F. when a fuel is used to run a gas producer for tank pressurization. To achieve such a temperature it is necessary to increase the proportion of ethylene carbonate relative to nitromethane. A 1200° F. decomposition solution may be achieved by employing 5% nitromethane, 25% ethylene carbonate and 70% ethylene oxide in proportion by weight.

In summary the principle of the invention relates to the method of varying the decomposition temperature of a solution by varying the proportions of its components such as alkylene carbonate and nitroalkane relative to one another. The resulting solution has improved characteristics relative to autoignition, storage density and vapor pressure. A second principle of the invention relates to the method of varying the proportion of alkylene oxide in a liquid monofuel to change the freezing point of the resulting solution, the main consideration being to employ as little alkylene oxide as possible and yet achieve a sufficiently low freezing point.

There have thus been described various liquid monofuel compositions useful in gas turbine engines and rocket reaction chambers and methods of adjusting the decomposition and storage characteristics of these compositions.

What is claimed is:

1. A fuel composition mixture consisting essentially of a major proportion by weight of at least one component selected from the group consisting of lower alkylene oxides and lower alkyl nitrates and a minor proportion by weight of at least one component selected from the group consisting of lower alkylene carbonates and lower nitro alkanes.

2. A fuel composition consisting essentially of a major proportion by weight of at least one lower alkylene oxide and at least one lower alkyl nitrate and a minor proportion by weight of at least one lower alkylene carbonate and at least one lower nitroalkane.

3. A fuel composition consisting essentially of a major proportion by weight of at least one lower alkylene oxide and a minor proportion by weight of at least one lower alkylene carbonate and at least one lower nitroalkane.

4. A fuel composition consisting essentially of a major proportion by weight of at least one lower alkylene oxide and a minor proportion by weight of at least one lower alkylene carbonate.

5. A fuel composition consisting essentially of a major proportion by weight of at least one lower alkylene oxide and a minor proportion by weight of at least one lower nitroalkane.

6. A fuel composition consisting essentially of a major proportion by weight of at least one lower alkyl nitrate and a minor proportion by weight of at least one lower alkylene carbonate and at least one lower nitroalkane.

7. A fuel composition consisting essentially of a major proportion by weight of at least one lower alkyl nitrate and a minor proportion by weight of at least one lower alkylene carbonate.

8. A fuel composition consisting essentially of a major proportion by weight of at least one lower alkyl nitrate and a minor proportion by weight of at least one lower nitroalkane.

9. A fuel composition consisting essentially of a major proportion by weight of ethylene oxide and a minor proportion by weight of nitromethane.

10. A fuel composition consisting essentially of a major proportion by weight of propylene oxide and a minor proportion by weight of nitromethane.

11. A liquid monopropellant for use in combustors consisting essentially of a major proportion by weight of ethylene oxide, and a minor proportion by weight of ethylene carbonate and nitromethane.

12. A liquid monopropellant for use in jet and rocket combustors, consisting essentially of a major proportion by weight of ethylene oxide and a minor proportion by weight of both ethylene carbonate and nitromethane, the proportions of the ethylene carbonate and nitromethane relative to each other being selected to achieve the decomposition temperature required for the combustor in which the monopropellant is to be employed.

13. A liquid monopropellant for use as a rocket and gas turbine fuel, consisting essentially of a major proportion of ethylene oxide, the balance being ethylene carbonate and nitromethane in substantially equal proportions by weight.

14. A gas turbine and rocket fuel, consisting essentially of the following ingredients and proportions by weight: 50% ethylene oxide, 25% nitromethane, 25% ethylene carbonate.

15. A gas turbine and rocket fuel, consisting essentially of the following ingredients and proportions by weight: 80% ethylene oxide, 10% nitromethane, 10% ethylene carbonate.

16. A gas turbine and rocket fuel, consisting essentially of the following ingredients and proportions by weight: 75% ethylene oxide, 20% nitromethane and 5% ethylene carbonate.

17. A rocket and gas turbine fuel, consisting essentially of the following ingredients in proportions by weight: 70% ethylene oxide, 5% nitromethane, 25% ethylene carbonate.

18. A liquid monopropellant consisting essentially of the following ingredients in proportions by weight: 40–80% ethylene oxide, 5–30% nitromethane and 5–30% ethylene carbonate.

19. A liquid monopropellant consisting essentially of the following ingredients in the following proportions by weight: 50–80% ethylene oxide, 10–25% nitromethane and 10–25% ethylene carbonate, the proportion of nitromethane being substantially equal to the proportion of ethylene carbonate.

No references cited.